SACRAMENTO MUNICIPAL UTILITY DISTRICT 100-MW_e PHOTOVOLTAIC POWER PLANT

JET PROPULSION LABORATORY

R.V. Powell

Chronology

- **SMUD unsolicited proposal to:**
  - **U.S. Department of Energy (DOE)**
  - **California Energy Commission (CEC)**
- **Congress mandated $6.8M for FY'82 for SMUD Project**
- **Negotiations for July 1982 start**

The SMUD Power-Plant Proposal

- **Unsolicited proposal (Dec. '81)**
- **100 MW in 10 phases - Rancho Seco site**
- **1 MW 1st phase - 24 months**
- **Design selected for 1st phase**
- **Alternative designs planned for later stages**
- **SMUD Project Manager**
- **CEC assist in environment impact**
- **Federal/State role is to share early cost risk**
- **Cooperative agreement**
- **Project Review Board**

PLENARY SESSION: R.V. POWELL

Special Features

- **Differential funding from government to limit cost/kW to a fixed value**
- **Government would be reimbursed when cost falls below fixed value**
- **Cost overruns would either be absorbed by SMUD or would result in a change of scope by the Project Review Board**

The Government Contract/Cooperative Agreement

- **DOE cooperative agreement, June '82**
- **CEC contract, June '82**
- **Limited to 1st 1 MW**
- **Alternative designs to be considered**
- **DOE/PV Design Assistance Team**
- **SMUD Project Manager**
- **Project Review Board**

OMIT

ENERGY ECONOMICS: DOES PHOTOVOLTAICS FIT IN?

SHELL OIL CO.

M. Sagenkahn

(Abridged)

1980 Energy Budget, Crude Oil Equivalents: MM bbl/day

	TRANSP	RES./ COM'L	INDUST	CHEM FDSTKS	EXPORTS	ELEC UTIL	SYN CRUDE	SYN GAS	TOTAL
OIL	8.5	2.4	2.9	1.0	0.5	1.4	-	-	16.7
GAS		3.7	4.0	0.3	-	1.8	-	-	9.8
COAL		0.1	1.6	-	1.1	5.8	-	-	8.6
NUCLEAR						1.2			1.2
HYDRO						1.4			1.4
SHALE							-		-
RENEWABLE						-			-
DELV'D ELECTRICITY		2.1	1.3			(3.4)			
TOTALS	8.5	8.3	9.8	1.3	1.6	8.2	-	-	37.7

Energy Growth in the United States, Crude Oil Equivalents: MM bbl/day

	1975		1980		1991		2000	
		%		%		%		%
OIL	15.5	46	16.7	44	16.2	38	14.1	30
GAS	9.5	28	9.8	26	7.5	18	6.8	14
COAL	6.9	20	8.6	23	12.8	30	19.7	41
NUCLEAR	.8	2	1.2	3	3.4	8	3.8	8
HYDRO	1.5	4	1.4	4	1.7	4	1.7	3
SHALE	-	-	-	-	0.5	1	1.0	2
RENEWABLE	-	-	-	-	0.4	1	0.9	2
TOTALS	34.2	100	37.7	100	42.5	100	48.0	100
		2.0% AAI*		1.1% AAI		1.4% AAI		

*ANNUALIZED AVERAGE INCREASE

U.S. Electric Utility Input Energy by Full Source, Crude Oil Equivalents: MM bbl/day

	1975		1980		1991		2000	
		%		%		%		%
OIL	1.5	16	1.4	12	0.9	6	0.8	4
GAS	1.6	17	1.8	16	1.3	9	0.9	5
COAL	4.1	43	5.8	50	7.9	52	11.4	61
NUCLEAR	0.8	8	1.2	10	3.4	22	3.8	20
HYDRO	1.5	16	1.4	12	1.7	11	1.7	9
RENEWABLE	-	-	-	-	0.1	-	0.2	1
DELV'D ELEC.	(2.8)		(3.4)		(4.6)		(5.8)	
TOTALS ENERGY INPUT	6.7		8.2		10.7		13.0	
		4.0% AAI		2.8% AAI		2.6% AAI		

PLENARY SESSION: M. SAGENKAHN

Solar Energy Forecast (Consistent With Total Energy Forecast)

- OF 0.9 MM BBL/DAY COE RENEWABLE ENERGY FORECAST TO 2000, 0.2 MM BBL/DAY WOULD BE SOLAR
- OF 0.2 MM BBL/DAY SOLAR, 20% WOULD BE PHOTOVOLTAIC
- THE 0.4 MM BBL/DAY PHOTOVOLTAIC WOULD BE DIVIDED ABOUT EQUALLY BETWEEN RESIDENTIAL/ COMMERCIAL, INDUSTRIAL AND ELECTRIC UTILITY

1991 Energy Budget, Crude Oil Equivalents: MM bbl/day

	TRANSP	RES./ COM'L	INDUST	CHEM FDSTKS	EXPORTS	ELEC UTIL	SYN CRUDE	SYN GAS	TOTAL
OIL	9.5	2.1	2.9	1.3	0.3	0.9	(0.9)	0.1	16.2
GAS		3.8	2.7	0.3	-	1.3	-	(0.6)	9.8
COAL		0.1	2.1	-	1.5	7.9	0.6	0.6	12.8
NUCLEAR						3.4			3.4
HYDRO						1.7			1.7
SHALE							0.5		0.5
RENEWABLE		0.1	0.2			0.1			0.4
DELV'D ELECTRICITY		2.8	1.8			(4.6)			
TOTALS	9.5	8.9	9.7	1.6	1.8	10.7	0.2	0.1	42.5

PLENARY SESSION: M. SAGENKAHN

2000 Energy Budget, Crude Oil Equivalents: MM bbl/day

	TRANSP	RES./ COM'L	INDUST	CHEM FDSTKS	EXPORTS	ELEC UTIL	SYN CRUDE	SYN GAS	TOTAL
OIL	9.4	1.7	2.8	1.5	0.3	0.8	(2.4)		14.1
GAS		4.8	1.9	0.5	-	0.9		(1.3)	6.8
COAL			2.5		1.7	11.4	2.5	1.6	19.7
NUCLEAR						3.8			3.8
HYDRO						1.7			1.7
SHALE							1.0		1.0
RENEWABLE		0.2	0.5			0.2			0.9
DELV'D ELECTRICITY		3.7	2.1			(5.8)			
TOTALS	9.4	10.4	9.8	2.0	2.0	13.0	1.1	0.3	48.0

Recent Energy Price Trends (Dec. 1980 to Sept. 1981)

	% AAI
PURCHASED INDUSTRIAL ELECTRICITY	21.5
CRUDE OIL (AV. REFINERS ACQUISITION COST)	9.0
NATURAL GAS (UTILITY COST)	46.0
COAL (UTILITY COST)	21.5

10 kW Diesel Generator

PREMISES

TOTAL INVESTMENT: $37M TODAY
$32M IN 15 YEARS
(EXPERIENCE CURVE EFFECT)

OPERATION & MAINTENANCE COSTS:
$5000/YR NOW
$4000/YR IN 15 YEARS

DIESEL PRICE: $1.00/GALLON AT REFINERY GATE
$0.40/GALLON DELIVERY

	NOW	15 YEARS HENCE		
		3%*	1%*	-1%*
REFINERY GATE	$1.00	$1.56	$1.16	$ .84
DELIVERY	.40	.35	.35	.35
DELIVERED DIESEL PRICE	$1.40/GAL	$1.91/GAL	$1.51/GAL	$1.91/GAL

DOES NOT INCLUDE ANY BATTERY STORAGE

*REAL CRUDE OIL RATE OF INCREASE

10 kW Photovoltaic System

PREMISES

TOTAL INVESTMENT: FOR $11/WP - $700M
$2.50/WP - $275M

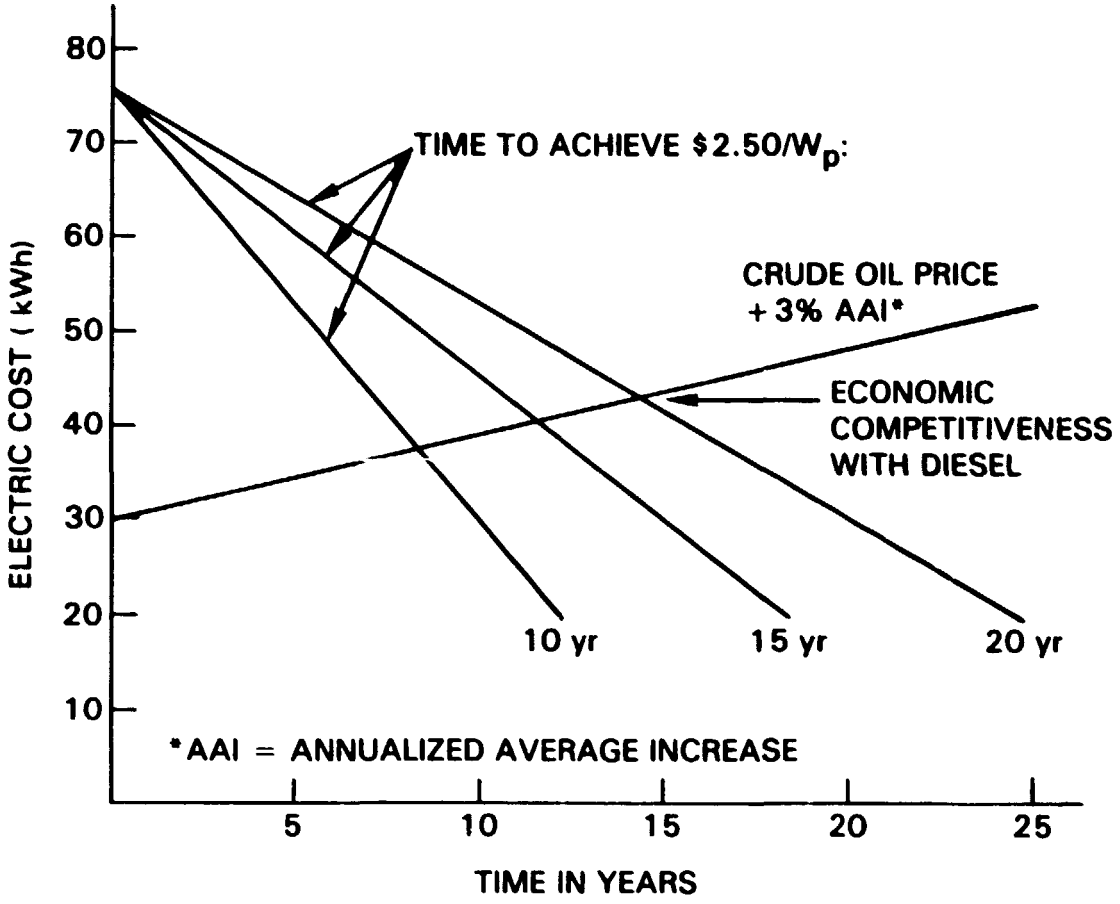
OPERATION & MAINTENANCE COSTS:
FOR $11/WP - $3000/YR
$2.50/WP - $2000/YR

LIFE OF SYSTEM - 20 YEARS

RETURN ON CAPITAL - 4% REAL

INCLUDES 1 DAY BATTERY STORAGE AT AN 80%
DEPTH OF DISCHARGE

Economic Comparison Between PV and Diesel-Generated Electricity for a 10 kW System



Conclusions

- THE EXTREMELY RAPID INCREASE IN ENERGY COSTS DURING THE PAST DECADE HAS:
  1. CAUSED DRAMATIC REDUCTIONS IN DEMAND
  2. IMPROVED SUPPLY AND THE SUPPLY OUTLOOK
- THE OUTLOOK FOR A COMFORTABLE U.S. ENERGY BALANCE TO THE END OF THIS CENTURY HAS BRIGHTENED CONSIDERABLY.
- THE PRESSURE FOR DEVELOPMENT OF RENEWABLE SOURCES OF ENERGY AND COAL CONVERSION PROCESSES HAS, AS A RESULT OF THE ABOVE, LESSENED.
- THESE DEVELOPMENTS WILL, OF COURSE, STILL BE NEEDED TO FILL SUBSTANTIAL PORTIONS OF THE FUTURE ENERGY DEMAND. THE CURRENT SITUATION SUGGESTS THIS TIMING TO BE WELL INTO THE NEXT CENTURY.
- THE EVENTUAL ECONOMIC COMPETITIVENESS OF PHOTOVOLTAICS FOR ANY GIVEN END USE IS, IN ANY EVENT, MORE A FUNCTION OF MANUFACTURING COST PER PEAK WATT OUTPUT THAN THE RATE OF REAL PRICE INCREASES OF TRADITIONAL ENERGY SOURCES.